



Christmas burst reveals neutron star collision

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Old model, new data: A match made in the heavens

LOS ALAMOS, New Mexico, December 1, 2011—A strangely powerful, long-lasting gamma-ray burst on Christmas Day, 2010 has finally been analyzed to the satisfaction of a multinational research team. Called the Christmas Burst, GRB 101225A was freakishly lengthy and it produced radiation at unusually varying wavelengths. But by matching the data with a model developed in 1998, the team was able to characterize the star explosion as a neutron star spiraling into the heart of its companion star.

The paper, “The unusual gamma-ray burst GRB 101225A from a helium star/neutron star merger at redshift 0.33,” appears in tomorrow’s issue of the journal *Nature*.

Christina Thöne of Spain’s Instituto de Astrofísica de Andalucía is the lead author, and Los Alamos computational scientist Chris Fryer is a contributor.

Fryer of the Lab’s Computer, Computational, and Statistical Sciences Division, realized that the peculiar evolution of the thermal emission (first showing X-rays with a characteristic radius of $\sim 10^{11}$ cm followed by optical and infra-red emission at $\sim 10^{14}$ cm) could be naturally explained by a model he and Stan Woosley of the University of California at Santa Cruz had developed in 1998.

“The Helium Merger Model explained all the properties we were seeing,” Fryer said, although he noted that proving this required a series of additional computational models by the international theory team studying this “Christmas burst” and the work still under way. Fryer is working with Wesley Even of the Los Alamos X Theoretical Design Division, using the U.S. Department of Energy’s Advanced Simulation and Computing codes to study the emission of this burst in more detail.

“What we think happened is that a primary neutron star was orbiting in a close binary relationship with a companion star, and the companion expanded into a gas giant phase and enveloped the neutron star,” Fryer said. “The neutron star spiraled into the core of the helium companion, with the friction of that passage ejecting the helium star’s envelope and creating a shell that produced the conditions needed to explain the different characteristic radii that we were seeing.”

When the neutron star transformed into a black hole and the jet of gamma rays blasted outward, it struck the shell of the old star’s gas envelope at 10^{14} centimeters, which produced anomalous results and made this GRB look very different from previously seen events. Normally GRBs are incredibly brief, powerful, and pretty much invisible astronomical events that are almost gone before they’re detected.

Since the 2004 launch of the NASA satellite Swift, which carries a device called a Burst Alert Telescope, with triggering software developed at Los Alamos, GRBs have been identified and documented on a regular basis. And when Swift tagged this Christmas Burst, the international teams jumped to their telescopes and computers to capture it. Identifying it, however, has taken nearly a year.

Having the existing model on hand, one that seemed unlikely to ever be tested in the real world, was a happy coincidence, Fryer said. “We really thought it was unlikely that the field would produce data sufficient to prove this neutron/helium star collision scenario, and yet, here it has done it.”

This burst may be one of a class of bursts (including XRF060218) that is explained by this model. “This is the game we’re in right now with astronomical transients,” Fryer said. “Weird objects can teach us a lot about the physics and we are no longer throwing them out as being too weird to explain. Now we can compare our unusual models to some of these unusual GRBs and they’re starting to match up.”

Los Alamos National Laboratory

www.lanl.gov

(505) 667-7000

Los Alamos, NM

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